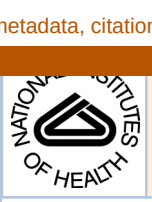

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It's Hard to Offend the College: Effects of Sentence Structure on Figurative-Language Processing

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Abstract

Previous research has given inconsistent evidence about whether familiar metonyms are more difficult to process than literal expressions. In two eye-tracking while reading experiments, we tested the hypothesis that the difficulty associated with processing metonyms would depend on sentence structure. Experiment 1 examined comprehension of familiar place-for-institution metonyms (e.g., *college*) when they were an argument of the main verb and showed that they are more difficult to process in a figurative context (e.g., *offended the college*) than in a literal context (e.g., *photographed the college*). Experiment 2 demonstrated that when they are arguments of the main verb, familiar metonyms are more difficult to process than frequency-and-length-matched nouns that refer to people (e.g., *offended the leader*), but that this difficulty was reduced when the metonym appeared as part of an adjunct phrase (e.g., *offended the honor of the college*). The results support the view that figurative-language processing is moderated by sentence structure. When the metonym was an argument of the verb, the results were consistent with the pattern predicted by the indirect-access model of figurative-language comprehension. In contrast, when the metonym was part of an adjunct phrase, the results were consistent with the pattern predicted by the direct-access model.

Keywords

metonymy; figurative language; sentence structure; eye movements

In everyday language comprehension we frequently encounter words that have multiple related meanings. For example, the word *college* can be used to refer to the physical space occupied by an institution of higher education, as in *Peter decided to leave the bike path and cut through the college*, or it can refer to the administration or other governing board of the institution, as in *Peter decided to petition the college to install more bike racks*. This latter example illustrates *metonymy,* a common type of figurative language in which some entity (e.g., *the administration of a university*) is referred to by some salient characteristic of that entity (e.g., *college*). Specifically, *petition the college* constitutes a place-for-institution metonym, where *college* does not refer to the literal, physical place, but rather to the larger institution associated with that place (Lakoff & Johnson, 1980). Other types of metonymy have also been documented. For example, the sentence *The ham sandwich is sitting at table*

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20 contains an object-used-for-user metonym, where *ham sandwich* does not refer to the literal sandwich, but rather to the customer who ordered the ham sandwich (Nunberg, 1978).

The manner in which metonymic expressions are understood factors into a general debate in the psycholinguistic literature over how we process figurative language. At a broad level, accounts of figurative-language processing differ in their predictions regarding the time course required to access a word's literal meaning compared to its figurative meaning. Psycholinguists have characterized the *standard pragmatic model* (Grice, 1975; Searle, 1979) as an *indirect-access model* of figurative-language processing in which the literal meaning of a figurative expression is always accessed before a figurative interpretation is computed. If there is a mismatch between the literal interpretation and the context of the sentence, the literal meaning is rejected and a figurative interpretation is adopted instead. Although this model received some early empirical support (e.g., Clark & Lucy, 1975; Janus & Bever, 1985), the strict "literal-first" account has been challenged by demonstrations that when there is sufficient context readers can access figurative interpretations just as quickly as they can access literal interpretations (e.g., Gerrig & Healy, 1983; Inhoff, Lima, & Carroll, 1984; Ortony, Schallert, Reynolds, & Antos, 1978; Shinjo & Myers, 1987), and by demonstrations that certain figurative interpretations are automatically activated, even when an appropriate literal interpretation is available (Gildea & Glucksberg, 1983; Glucksberg, Gildea, & Bookin, 1982; Keysar, 1989). These findings have been taken as evidence for a *direct-access model* (Gibbs, 1994; Gibbs & Gerrig, 1989; Glucksberg, 1991, 2003) according to which neither a literal nor a figurative interpretation takes priority, but where contextual and lexical information interact immediately, allowing rapid selection of the intended meaning of a word. With increasing evidence that familiar figurative expressions are not necessarily more difficult to process than literal expressions (for reviews, see Glucksberg, 2001, 2003), researchers have shifted from the indirect-access model and toward the direct-access model.

Models of figurative-language processing have been based primarily on the comprehension of metaphor, with very few experimental studies examining the processing of metonymy. Some evidence suggests that familiar metonyms are no more difficult to process than literal expressions. Frisson and Pickering (1999) conducted two eye-tracking while reading experiments that investigated the processing of familiar versus unfamiliar metonyms that appeared in either a literal or figurative context. In their Experiment 1, participants read sentences like those presented in (1). Here, *college* is a familiar place-for-institution metonym that can easily appear in either a literal context (1a) or a figurative context (1c). In contrast, *pyramid* has no familiar metonymic sense, and so it can easily appear in a literal context (1b), but it has no straightforward interpretation when it appears in a figurative context (1d).

(1a) The photographer stepped inside the college after he had received an official invitation.

(1b) The photographer stepped inside the pyramid after he had received an official invitation.

(1c) That bright boy was rejected by the college after he had bribed some crooked officials.

(1d) That bright boy was rejected by the pyramid after he had bribed some crooked officials.

Reading times on both the critical noun phrase (NP) and on the postnoun region revealed substantial processing difficulty when an unfamiliar metonym appeared in a figurative context (1d) compared to the other three conditions. In contrast, there was only weak

evidence that the familiar metonym in a figurative context (1c) was more difficult than in a literal context (1a), and this effect emerged relatively late in the eye-tracking record. Frisson and Pickering's Experiment 2 found a similar pattern of results using familiar and non-familiar place-for-event metonyms (e.g., *Vietnam* can refer literally to the country or figuratively to the Vietnam war, whereas *Finland* has no familiar metonymic sense). Frisson and Pickering interpreted these results as supporting an account of figurative-language processing in which readers do not initially distinguish between the literal and figurative meaning of a familiar metonym, but rather adopt a single, underspecified meaning and only later activate the intended sense. This account differs from earlier direct-access models (Gibbs, 1994; Gibbs & Gerrig, 1989; Glucksberg, 1991, 2003): whereas a direct-access account proposes that similar processing patterns for literal and figurative expressions are the result of the rapid influence of sentence context, the underspecification account instead argues that there is no difference between the processing of literal and figurative expressions because the reader does not make a strong initial commitment to either interpretation (for further discussion of the underspecification approach, see Frisson, 2009; Frisson & Pickering, 2001). Additional work has supported the idea that familiar metonymic interpretations are no more difficult to access than literal interpretations for both young and older adults (Humphrey, Kemper, & Radel, 2004) and in cases of producer-for-product metonyms (Frisson & Pickering, 2007; McElree, Frisson, & Pickering, 2006).

In contrast, other studies present evidence that the figurative meaning of a metonym is more difficult to access than its literal meaning. Gibbs (1990) presented participants with short narratives (e.g., a story about an incompetent surgeon) where the final sentence contained a referring expression that could be literal, metaphoric, or metonymic (e.g., *The doctor/butcher/scalpel was sued for malpractice*). He found that participants had the least difficulty establishing an antecedent in the literal condition compared to the two figurative conditions. However, participants were significantly slower in the metonymic condition compared to the metaphoric condition, leading Gibbs to conclude that metonymic referential expressions are more difficult to understand than other types of referential expressions (see also Onishi & Murphy, 1993). Frisson and Pickering (1999) noted that Gibbs did not make a distinction between *sense selection* and *sense creation*. That is, the metonym condition in this study may have been more difficult than the others because readers are not used to referring to a doctor as a *scalpel*, and so they had to generate this novel sense of the word. This contrasts with a familiar metonym (e.g., *college*), where readers do not have to generate the meaning, but rather select it among several possible senses (see Clark & Gerrig, 1983; Gerrig, 1989). Additional research using neuroimaging (Rapp, Erb, Grodd, Bartels, & Markert, 2011), electrophysiology (Weiland, Bambini, & Schumacher, 2012), and speed-accuracy trade-off methodology (Ghio, Bott, Schumacher, & Bambini, 2012) has also shown clear differences in the processing of metonymic versus literal expressions.

In this paper, we propose that metonymic processing is influenced by sentence structure, which determines whether processing conforms to predictions derived from the indirect-access model or the direct-access model. This approach is consistent with a variety of psycholinguistic perspectives that have proposed that sentence structure guides the depth at which language comprehenders interpret referential expressions and relations between parts of a sentence (e.g., Baker & Wagner, 1987; Ferreira, Bailey, & Ferraro, 2002; Gordon & Hendrick, 1998; Sanford & Sturt, 2002). In particular, we test the hypothesis that metonyms are more difficult to process than literal expressions when they appear as an argument of a verb, but that this processing difficulty is reduced when the metonym appears as part of an adjunct phrase. This hypothesis was driven in part by our recent work (Lowder & Gordon, 2012) showing that changes in sentence structure affect the processing difficulty associated with integrating an inanimate sentence subject with an action verb (this work pertains to questions about how noun animacy influences complex-sentence processing: see Gordon &

Lowder, 2012, Traxler, Morris, & Seely, 2002; Traxler, Williams, Blozis, & Morris, 2005; and questions about how information specified by arguments and adjuncts is processed: Boland & Blodgett, 2006; Clifton, Speer, & Abney, 1991; Schutze & Gibson, 1999; Speer & Clifton, 1998). Lowder and Gordon recorded participants' eye movements while they read sentences like those in (2), where the sentence subject was either animate or inanimate and where an action verb appeared as either the main verb of the sentence or as part of a relative clause (i.e., an adjunct phrase). Lowder and Gordon found substantial processing difficulty at the verb for inanimate subjects versus animate subjects in a simple sentence context (2b versus 2a); however, there was no such animacy difference when the action verb was embedded in a relative clause (2d versus 2c)[1]. This work demonstrated an important role for sentence structure in subject-verb integration. That is, the pairing of an inanimate subject with an action verb (e.g., *The pistol injured*) is difficult when this relationship is focused by virtue of being in the main clause of the sentence. In contrast, this difficulty is reduced when the integration takes place within a relative clause (e.g., *The pistol that injured*), presumably because the structure of the sentence signals to the reader that the information in this adjunct phrase is less important and thus requires less attention than the new information being asserted in the main clause of the sentence. This work also suggests that there may be other semantic characteristics of a sentence aside from animacy whose ease or difficulty of processing depends critically on sentence structure.

(2a) The cowboy concealed the pistol last night in the saloon.

(2b) The pistol injured the cowboy last night in the saloon.

(2c) The cowboy that concealed the pistol was known to be unreliable.

(2d) The pistol that injured the cowboy was known to be unreliable.

The notion that interactions between semantics and syntax of the sort reported by Lowder and Gordon (2012) might extend into research on figurative language is supported by the observation that several of the inanimate critical nouns used in that study could be interpreted metonymically (although in most cases the metonymic sense of the inanimate noun likely has to be created, rather than selected from an established metonymic sense). For example, an inanimate subject-verb pair such as *pistol injured* in (2b) resembles what Lakoff and Johnson (1980) called object-used-for-user-metonyms (e.g., *The gun he hired wanted fifty grand*), where in this case *pistol* could stand for *the man who was holding the pistol* or *someone's shooting of the pistol* (other examples of object-used-for-user metonyms from Lowder and Gordon include *the revolver shot* and *the wrench bruised*). In line with this perspective, Pustejovsky (1995) has proposed that sentences like (3b) require a metonymic interpretation. Whereas the animate entity *John* can easily be integrated with an action verb like *killed* in (3a), Pustejovsky proposes that we instead process (3b) by type-shifting the inanimate entity *the gun* from an object to an event involving an animate agent (e.g., *someone's shooting of the gun*). This semantic type-shifting process is called *coercion*.

(3a) John killed Mary.

(3b) The gun killed Mary.

We propose that inanimate subject-verb integration, coercion, metonymic processing, and other types of figurative language share a common source of processing difficulty in that

[1]The greater processing difficulty for sentences like (2b) versus (2a) is unlikely to be due to temporary ambiguity at the verb between a main clause interpretation and a reduced-relative clause interpretation. First, the inanimate nouns used in Lowder and Gordon (2012) could not plausibly serve as the patient of an action verb (e.g., *The pistol injured by the cowboy…* is anomalous). More importantly, the greater difficulty observed in sentences like (2b) compared to (2d) was completely localized to the verb. If readers had entertained the possibility of a reduced-relative interpretation in (2b), then greater processing difficulty should have been observed on the subsequent, unambiguous NP (e.g., *the cowboy*) for (2b) compared to (2d).

they all require that a word be given a noncanonical semantic interpretation so that it makes sense in relation to the meanings of other parts of the sentence. Sentence structure acts as one of several factors that can either emphasize or deemphasize the relevant semantic relation and therefore the need to make the noncanonical interpretation. In other words, a reader's limited attentional resources are guided to a large extent by sentence structure, such that certain elements and relations are processed deeply at the expense of other elements and relations. Specifically, when these sentential elements appear as arguments of a verb, their interpretation is critical to the overall coherence of the sentence, and so they are processed at a deep level, which leads to processing difficulty. In contrast, when these sentential elements are embedded in an adjunct phrase, they are seen as being less important to the meaning of the sentence, and so they are processed less deeply. This occurs because adjuncts are modifiers, and their interpretation does not depend strongly on the interpretation of the heads they modify (Schutze & Gibson, 1999). In addition, an adjunct phrase may signal to the reader that the information it contains is presupposed, and thus is not as important to focus on as the "new" information being asserted in the main clause of the sentence. We address several possible mechanisms that may explain differences in depth of processing in the General Discussion.

Lowder and Gordon's (2012) finding of greater processing difficulty for (2b) versus (2a) demonstrates that noncanonical arguments in the form of inanimate subjects cause processing difficulty when combined with an action verb. Critically, this cost is reduced when the subject-verb integration takes place in an adjunct phrase. The current paper extends these findings to figurative-language processing by demonstrating that the figurative interpretation of a metonym is more difficult to process than a literal expression when the critical word appears as the argument of the verb, but that this difference is reduced when the critical word is embedded in an adjunct phrase.

Experiment 1

Experiment 1 employed the metonyms and the basic design of Frisson and Pickering (1999) but modified their stimulus sentences so that the critical metonym was always an argument of the verb. As discussed above, Frisson and Pickering's Experiment 1 investigated the processing of place-for-institution metonyms as shown in (1; repeated here).

(1a) *The photographer stepped inside the college after he had received an official invitation.* (Literal-Familiar)

(1b) *The photographer stepped inside the pyramid after he had received an official invitation.* (Literal-Unfamiliar)

(1c) *That bright boy was rejected by the college after he had bribed some crooked officials.* (Metonymic-Familiar)

(1d) *That bright boy was rejected by the pyramid after he had bribed some crooked officials.* (Metonymic-Unfamiliar)

The critical NP in (1a) and (1c) is *the college*. In (1a), *college* is interpreted literally (i.e., the physical college campus), whereas in (1c), *college* is interpreted figuratively (i.e., the people who make up the admissions committee at the college). The critical NP in (1b) and (1d) is *the pyramid*. In (1b), *pyramid* is interpreted literally; however, there is no familiar metonymic sense associated with *pyramid*, and so (1d) is anomalous. We use the labels Literal and Metonymic to refer to the sentence context in which the critical word appears. We use the labels Familiar and Unfamiliar to refer to whether the target word has a familiar metonymic sense or not.

Whereas the indirect-access model predicts greater difficulty processing (1c) compared to (1a), the direct-access model predicts that there should be no difference. Frisson and Pickering (1999) tested these predictions in an eye-tracking while reading experiment using sentences like in (1). Across several eye-tracking measures, they found robust context-by-metonym-familiarity interactions on the region immediately before the critical NP, on the critical NP itself, and on the region immediately following the critical NP. Follow-up analyses showed that the driving force behind these interactions was extreme processing difficulty associated with the Metonymic-Unfamiliar condition (e.g., *rejected by the pyramid*), which led Frisson and Pickering to conclude that whereas unfamiliar metonyms are difficult to process, familiar metonyms are processed very easily whether they appear in a literal or figurative context. Of particular interest, the greater difficulty for the Metonymic-Unfamiliar condition over the other three conditions emerged in first-pass reading of the critical NP, suggesting that early stages of lexical access are sensitive to metonymic processing. Whereas lexical access was difficult for a word that was used in an unfamiliar metonymic context compared to when it was used in its literal context (e.g., *rejected by the pyramid* versus *stepped inside the pyramid*), there was no difference when the critical word had a familiar metonymic sense (e.g., *rejected by the college* versus *stepped inside the college*). This outcome supports the direct-access model in showing that readers used the context of the sentence to rapidly determine which sense of a familiar metonym to select; because there is no familiar figurative sense associated with *pyramid*, a process of sense creation must take place. The results also support Frisson and Pickering's underspecification model, where the reader initially activates only an underspecified meaning of a familiar metonym and later selects the appropriate sense.

Notwithstanding this conclusion, Frisson and Pickering (1999) did obtain some evidence that Metonymic-Familiar (e.g., *rejected by the college*) was more difficult than Literal-Familiar (*stepped inside the college*). Specifically, they found that readers were more likely to regress to earlier regions of the sentence after having read the critical NP in the Metonymic-Familiar compared to the Literal-Familiar. Also, there was evidence for greater total reading times for the Metonymic-Familiar condition than for the Literal-Familiar condition on both the critical NP as well as the region immediately following it. Frisson and Pickering acknowledge these differences, but note that these effects were relatively weak. Furthermore, Frisson and Pickering point out that the greater difficulty associated with the Metonymic-Unfamiliar condition emerged early in the eye-tracking record, whereas the smaller difference between the Metonymic-Familiar and Literal-Familiar conditions did not emerge until later processing measures. Thus, Frisson and Pickering claim that their results offer only weak support for the indirect-access model.

In Experiment 1 we tested the hypothesis that a clear processing difference between familiar metonyms used in their literal versus figurative contexts would emerge in a set of materials that more carefully controls the sentence position of the critical NP (see 4 for an example). Specifically, we modified Frisson and Pickering's (1999) materials in two important ways. First, we rewrote the verb phrase of each set of items such that the critical NP would always appear as the object of the verb. Although this was already the case in some of Frisson and Pickering's materials (e.g., *the famous drug smuggler provoked the court; the grateful old lady thanked the store*), it was more often the case that the critical NP appeared as part of an adjunct phrase (e.g., *the bright boy was rejected by the college; the guards got instructions from the headquarters*), or at least followed a preposition that intervened between the verb and the noun (e.g., *the young expert cooperated with the gallery; that blasphemous young woman had to answer to the convent*). This variability in sentence structure occurred not only within the figurative contexts, as in the above examples, but also in the literal contexts (compare, e.g., *those angry protestors surrounded the embassy* and *the cab driver dropped us off at the treasury*). Second, Frisson and Pickering used different sentence frames within a

set of items to evoke the literal versus figurative sense of the critical word (compare 1a and 1b to 1c and 1d). This was done to allow two items within a set to appear on the same experimental list (e.g., 1a and 1d were paired together). We take a similar approach to our design; however, we also constructed additional sentences to increase our total number of items.

(4a) *Sometime in August, the journalist photographed the college after he had received an official invitation.* (Literal-Familiar)

(4b) *Sometime in August, the journalist photographed the pyramid after he had received an official invitation.* (Literal-Unfamiliar)

(4c) *Sometime in August, the journalist offended the college after he had bribed some crooked officials.* (Metonymic-Familiar)

(4d) *Sometime in August, the journalist offended the pyramid after he had bribed some crooked officials.* (Metonymic-Unfamiliar)

As discussed above, Lowder and Gordon (2012) demonstrated that sentence structure moderates semantic integration, with processing difficulty emerging when a noncanonical argument is paired with an action verb. Similarly, we predicted that readers would experience difficulty processing both familiar and unfamiliar metonyms when the critical word appeared as an argument of the verb. Critically, because the metonym involves a noncanonical interpretation and is focused by virtue of its being an argument of the verb, this greater difficulty for metonyms used in a figurative versus a literal context should emerge early in the eye-tracking record and should not depend on familiarity of the metonym. Based on the results of Frisson and Pickering (1999), we also predicted that readers would experience greater difficulty processing unfamiliar metonyms compared to familiar metonyms, but we expected this difficulty to emerge relatively late in the eye-tracking record.

Method

Participants—Twenty-eight students at the University of North Carolina at Chapel Hill participated in this experiment in exchange for course credit. They were all native English speakers and had normal or corrected-to-normal vision.

Materials—Each participant was presented with 32 experimental sentences and 92 filler sentences. The experimental sentences were adapted from Frisson and Pickering (1999, Experiment 1). Everything from the critical NP to the end of the sentence was identical to the materials used by Frisson and Pickering. Critically, we changed the verb phrases such that they always consisted of only one word, which would then take the critical NP as its object. This required us to change the sentence subject in some cases, but not in others. Finally, we began every sentence with a locative phrase. See (4) for an example.

Each set of items was yoked to another set of items that contained the same verbs and critical NPs but contained a different locative phrase and a different sentence subject (see 5). This was done to allow pairing of items across four lists, but to also maintain tight experimental control. Thus, in constructing our counterbalanced lists, (4a) and (5d) always appeared together, as did (4b) and (5c), and so on. See Appendix A for a full list of materials.

(5a) *Over the summer, the writer photographed the college after he had received an official invitation.* (Literal-Familiar)

(5b) *Over the summer, the writer photographed the pyramid after he had received an official invitation.* (Literal-Unfamiliar)

(5c) *Over the summer, the writer offended the college after he had bribed some crooked officials.* (Metonymic-Familiar)

(5d) *Over the summer, the writer offended the pyramid after he had bribed some crooked officials.* (Metonymic-Unfamiliar)

The critical nouns we used (e.g., *college* versus *pyramid*) came directly from Frisson and Pickering (1999), who had carefully balanced them for frequency and length. Likewise, we selected verbs for the literal and metonymic contexts that did not differ significantly in frequency, $t(30) = 1.17$, $p > .24$ (SUBTLEXus database, Brysbaert & New, 2009), and that were identical in length. Frisson and Pickering had demonstrated that there were no differences in average frequencies of the literal and figurative senses of the familiar metonyms.

Plausibility norming—To test for differences in plausibility among the four conditions, we presented the stimuli from Experiment 1 up to and including the critical noun (e.g., *Over the summer, the writer photographed the college.*) to 20 participants who did not participate in the eye-tracking experiment. There were four versions of each list that were counterbalanced into the same lists used for the eye-tracking experiment. Each list also contained filler sentences. Participants were instructed to indicate how likely they believed the events described by the sentence were on a scale from 1 (highly unlikely) to 7 (highly likely). Each participant saw the sentences in a different random order. The mean ratings for each condition were 5.5 (Literal-Familiar), 5.5 (Literal-Unfamiliar), 4.7 (Metonymic-Familiar), and 2.4 (Metonymic-Unfamiliar). All pairwise comparisons differed significantly from each other except for the two Literal conditions, all ts > 2.6, all ps < .05. This pattern of plausibility results is identical to the pattern obtained by Frisson and Pickering (1999). Although the Literal-Familiar and Metonymic-Familiar conditions were significantly different from one another, the magnitude of this difference was quite small, especially compared to the larger difference between the Metonymic-Familiar and Metonymic-Unfamiliar conditions (see also Footnote 2).

Predictability—A group of 16 participants, none of whom participated in any other aspect of the study, were presented with the stimuli from Experiment 1 up to and including the determiner before the critical noun (e.g., *Over the summer, the writer photographed the …*) and were instructed to complete each fragment. The fragments were presented in one of four possible orderings. Participants' responses were then compared with the actual experimental stimuli to assess how predictable the critical words were. The percentages of responses that matched the critical words were extremely low across all conditions: 0.4% (Literal-Familiar), 0.4% (Literal-Unfamiliar), 1.2% (Metonymic-Familiar), and 0% (Metonymic-Unfamiliar).

Procedure—Participants' eye movements were recorded with an EyeLink 1000 system (SR Research) at a sampling rate of 1000 Hz with a headrest used to minimize movement. At the start of each trial, a fixation point was presented near the left edge of the monitor, marking the location where the first word of the sentence would appear. When the participant fixated this point, the experimenter pressed a button that replaced the fixation point with the sentence. After reading the sentence, the participant pressed a key, which made the sentence disappear and a true-false comprehension question appear. Participants pressed one key to answer "true," and another key to answer "false." A comprehension question followed every sentence.

Each experimental session began with four filler sentences. After this warm-up block, the remaining 120 sentences were presented in a different random order for each participant.

Analysis—Data analysis focused on four standard eye-movement measures. *Gaze duration* is the sum of all initial fixations on a region; it begins when the region is first fixated and ends when gaze is directed away from the region, either to the left or right. *Right-bounded reading time* (also called *quasi-first pass time*) is similar to gaze duration, except it ends when gaze is directed away from the region to the right. This measure is not discussed as often as the others reported here, but it has nevertheless been used in several eye-tracking while reading studies (e.g., Betancort, Carreiras, & Sturt, 2009; Gordon, Hendrick, Johnson, & Lee, 2006; Lee, Lee, & Gordon, 2007; Traxler et al., 2002). *Regression-path duration* (also called *go-past time*) is the sum of all fixations beginning with the initial fixation on a region and ending when the gaze is directed away from the region to the right. Thus, regression-path duration includes right-bounded reading time, but also includes any regressive fixations to earlier parts of the sentence. *Total time* is the sum of all fixations on a word or region. For our analyses of these measures, we excluded 0-ms times, which occur when a critical region is skipped during first pass (e.g., Frisson & Pickering, 1999; Pickering & Traxler, 1998, 2001). Throughout the paper, we use gaze duration to assess the earliest stages of processing, right-bounded reading time and regression-path duration to assess intermediate stages of processing, and total time to assess global processing difficulty.

We report reading times for three regions of interest. The *prenoun region* consisted of the subject of the sentence (bare noun only) and the main verb (e.g., *journalist photographed*/*journalist offended*). The *critical NP* consisted of the target word along with the determiner (e.g., *the college*/*the pyramid*). The *postnoun region* consisted of the three words following the critical NP in most cases (e.g., *after he had*). Note that these words are the same across the literal and metonymic conditions. In four of our item sets, only two words remained constant between conditions. Following Frisson and Pickering (1999), the postnoun region for those items consisted of only those two words. When two or more consecutive regions were skipped during first pass, the trial was excluded.

An automatic procedure in the Eyelink software combined fixations that were shorter than 80 ms and within one character of another fixation into one fixation. Additional fixations shorter than 80 ms and longer than 1,000 ms were removed. For all reading-time measures, we set minimum cutoff values at 120 ms. Maximum cutoff values were set at 1,500 ms for gaze duration and 3,000 ms for all other measures (for similar approaches see, e.g., Frisson & McElree, 2008; Frisson & Pickering, 2007; McElree et al., 2006; Tooley, Traxler, & Swaab, 2009; Traxler, 2009; Traxler & Tooley, 2008). This procedure eliminated 1.6% of the data.

Results

Comprehension-question accuracy—Mean comprehension-question accuracies for each condition were as follows: Literal-Familiar (97%), Literal-Unfamiliar (95%), Metonymic-Familiar (94%), Metonymic-Unfamiliar (90%). Because these values were all extremely close to the upper limit of the distribution, the data were arcsine-transformed prior to calculation of inferential statistics (Cohen, Cohen, West, & Aiken, 2003; for a similar approach, see, e.g., Johnson, Lowder, & Gordon, 2011). The analysis revealed a main effect of context that was only significant in the subject analysis, $F_1(1, 27) = 8.60$, $MSE = .10$, $p < .01$; $F_2(1, 31) = 2.32$, $MSE = .30$, $p > .13$. Although this difference was unexpected, we do not attribute it to differences in the processing of literal versus figurative expressions. Rather, it is important to note that the comprehension questions following sentences in the literal condition were different from the questions following sentences in the metonymic condition due to the differences in sentence frames. Furthermore, the questions following sentences in the metonymic condition never probed the reader's interpretation of the critical word. For example, the question following (5c) and (5d) was, "True or False: The writer was

of the highest morals." It thus seems possible that differences in the difficulty of the questions between the literal and figurative conditions are responsible for the slight differences in accuracy. However, because this effect did not approach significance in the item analysis and because accuracy was very high across all conditions, we do not place much weight on this finding. The main effect of metonym familiarity and the interaction between context and familiarity were not significant.

Prenoun region—Mean reading times for the three regions of interest are displayed in Table 1. Reading times from all trials were included, regardless of whether the comprehension question was answered correctly. No statistically significant main effects or interactions were observed in the prenoun region for gaze duration, right-bounded reading time, or regression-path duration, demonstrating that processing difficulty for the four conditions did not differ prior to encountering the critical NP.

In contrast, the prenoun region showed a robust main effect of context for total time, such that there were longer reading times on the prenoun region for the metonymic contexts compared to the literal contexts, $F_1(1, 27) = 26.91$, $MSE = 20{,}276$, $p < .001$; $F_2(1, 31) = 19.52$, $MSE = 29{,}707$, $p < .001$. There was no main effect of metonym familiarity, $F_1(1, 27) = 1.94$, $MSE = 46{,}948$, $p > .15$; $F_2(1, 31) = 1.16$, $MSE = 62{,}835$, $p > .25$, nor was there any evidence of a context-by-familiarity interaction, $F_1(1, 27) < 1$; $F_2(1, 31) < 1$. This pattern suggests that readers experienced processing difficulty when they encountered a noun that had to be interpreted figuratively, causing them to go back and reread earlier parts of the sentence.

Critical NP—Measures assessing early and intermediate stages of processing on the critical NP showed that metonyms were more difficult to process than literal expressions, regardless of metonym familiarity. Analysis of gaze duration on the critical NP revealed a significant main effect of context, $F_1(1, 27) = 8.77$, $MSE = 3{,}526$, $p < .01$; $F_2(1, 31) = 5.91$, $MSE = 5{,}922$, $p < .05$, with longer reading times for the metonymic contexts compared to the literal contexts[2]. There was no main effect of metonym familiarity, $F_1(1, 27) < 1$; $F_2(1, 31) < 1$, nor was there a context-by-familiarity interaction, $F_1(1, 27) = 1.19$, $MSE = 3{,}906$, $p > .28$; $F_2(1, 31) = 1.13$, $MSE = 6{,}716$, $p > .29$.

The main effect of context was also significant in both right-bounded reading time, $F_1(1, 27) = 10.04$, $MSE = 7{,}934$, $p < .005$; $F_2(1, 31) = 5.40$, $MSE = 14{,}024$, $p < .05$, and in regression-path duration, $F_1(1, 27) = 5.80$, $MSE = 31{,}365$, $p < .05$; $F_2(1, 31) = 6.30$, $MSE = 27{,}093$, $p < .05$. These two measures showed no main effects of metonym familiarity and no context-by-familiarity interaction, all Fs < 1.2. Thus, analysis of gaze duration, right-bounded reading time, and regression-path duration at the critical NP all suggest greater processing difficulty when the critical NP appeared in a metonymic context compared to a literal context, and there was no evidence that familiar metonyms were easier to process than unfamiliar metonyms[2].

In contrast, analysis of total time on the critical NP revealed a significant context-by-familiarity interaction, $F_1(1, 27) = 12.27$, $MSE = 17{,}169$, $p < .005$; $F_2(1, 31) = 7.78$, $MSE = 26{,}210$, $p < .01$. Follow-up analyses with planned comparisons showed that the Metonymic-Unfamiliar condition was more difficult than the Literal-Unfamiliar condition, $t_1(27) = 5.64$,

[2]To determine whether the greater processing difficulty associated with familiar metonyms compared to literal expressions could be explained by plausibility differences between these two conditions, we correlated the difference in reading times between items in the Metonymic-Familiar and Literal-Familiar conditions with the difference in their plausibility ratings. This correlation was performed for all regions of interest on every eye-tracking measure that showed an effect of context. There was no indication that plausibility differences had any influence on reading times, all rs < .18, all ps > .32.

$p < .001$; $t_2(31) = 5.31$, $p < .001$, but that there was no difference between the Metonymic-Familiar condition and the Literal-Familiar condition, $t_1(27) = 1.23$, $p > .20$; $t_2(31) = 1.19$, $p > .20$.

Postnoun region—No statistically significant main effects or interactions were observed for gaze duration in the postnoun region. Analysis of right-bounded reading time in the postnoun region revealed a significant main effect of context, $F_1(1, 27) = 7.84$, $MSE = 6{,}028$, $p < .01$; $F_2(1, 31) = 6.90$, $MSE = 9{,}479$, $p < .05$ and a marginally significant context-by-familiarity interaction, $F_1(1, 27) = 3.33$, $MSE = 5{,}847$, $p < .08$; $F_2(1, 31) = 3.89$, $MSE = 7{,}998$, $p < .06$. The context-by-familiarity interaction was fully significant for regression-path duration, $F_1(1, 27) = 8.23$, $MSE = 23{,}113$, $p < .01$; $F_2(1, 31) = 6.71$, $MSE = 32{,}664$, $p < .05$. Planned comparisons showed that the Metonymic-Unfamiliar condition was more difficult than the Literal-Unfamiliar condition, $t_1(27) = 4.12$, $p < .001$; $t_2(31) = 3.51$, $p < .005$, but that there was no difference between the Metonymic-Familiar condition and the Literal-Familiar condition, $t_1(27) < 1$; $t_2(31) = < 1$. For total time on the postnoun region, there was a main effect of metonym familiarity that was significant only in the subjects analysis, $F_1(1, 27) = 4.44$, $MSE = 9{,}878$, $p < .05$; $F_2(1, 31) = 2.66$, $MSE = 19{,}544$, $p > .10$. There was no significant main effect of context, $F_1(1, 27) = 2.11$, $MSE = 14{,}464$, $p > .15$; $F_2(1, 31) = 1.99$, $MSE = 24{,}605$, $p > .15$, nor was there a context-by-familiarity interaction, $F_1(1, 27) < 1$; $F_2(1, 31) < 1$.

Discussion

The results of Experiment 1 show that both familiar and unfamiliar metonyms cause processing difficulty, but that the difficulty caused by unfamiliar metonyms is more prolonged than that for familiar metonyms. Measures reflecting early and intermediate stages of processing (gaze duration, right-bounded reading time, and regression-path duration) on the critical NP showed that figurative expressions were more difficult than literal expressions, regardless of the familiarity of the metonym. The greater overall difficulty for figurative expressions over literal expressions persisted in right-bounded reading time on the postnoun region, and total time on the prenoun region.

We also found evidence that the Metonymic-Unfamiliar condition (e.g., *offended the pyramid*) was more difficult than the Metonymic-Familiar condition (e.g., *offended the college*); however, this effect did not emerge until relatively late in the eye-tracking record (regression-path duration on the postnoun region and total time on the critical NP). This pattern contrasts with the results reported by Frisson and Pickering (1999), who demonstrated that greater difficulty processing their Metonymic-Unfamiliar condition (e.g., *rejected by the pyramid*) compared to their Metonymic-Familiar condition (e.g., *rejected by the college*) emerged early (i.e., in gaze duration on the critical NP).

The overall pattern of the results of Experiment 1 is consistent with the indirect-access model of figurative-language processing. According to this model, the literal meaning of a figurative expression is always accessed before the figurative meaning, which results in early processing difficulty when a metonym is first encountered—even if the figurative meaning of the metonym is well-established. However, the model also predicts that readers should experience longer-lasting difficulty with an unfamiliar metonym compared to a familiar metonym (Frisson & Pickering, 1999). Presumably this occurs because whereas the figurative sense of a familiar metonym can be *selected* among its various possible meanings, the figurative sense of an unfamiliar metonym must be *created*, which requires additional processing time.

We propose that the discrepant findings between the current study and Frisson and Pickering (1999) can be explained by taking sentence structure into consideration. Whereas the critical

NPs in our Experiment 1 always appeared as an argument of the main verb of the sentence, the critical NPs used by Frisson and Pickering varied in their syntactic role, sometimes occurring as an argument of the verb, but more often appearing as part of an adjunct phrase, which may have reduced the processing difficulty associated with the metonym. We believe that this occurs because the structure of our sentences focused the reader's attention on this noncanonical semantic relationship, leading to deeper interpretation compared to a sentence where the metonym and the verb, while related in the sentence, have greater separation within the structure of the sentence. This notion is consistent with Lowder and Gordon (2012), who showed that inanimate subject-verb integration is difficult when the subject is an argument of the main verb of the sentence (e.g., *the pistol injured*), but that this difficulty is reduced when the verb is embedded in an adjunct phrase (e.g., *the pistol that injured*). This latter finding of Lowder and Gordon leads to the prediction that metonymic processing difficulty should be reduced when the metonym appears as part of an adjunct phrase compared to when it is an argument.

Experiment 2

Experiment 2 tested the hypothesis of Lowder and Gordon (2012) that sentence structure guides the depth to which readers interpret meaningful relations between parts of sentences by examining whether the processing difficulty found in Experiment 1 for familiar metonyms would be reduced when they appeared as part of an adjunct phrase compared to when they appeared as an argument of the verb. Specifically, Experiment 2 examined the processing of sentences like those presented in (6). A comparison of (6c) versus (6d) provides a test of the hypothesis that metonymic processing depends on sentence structure. Support for this hypothesis would help reconcile conflicting results on whether there is a processing cost associated with interpretation of metonyms (Frisson & Pickering, 1999, 2007; Ghio et al., 2012; Gibbs, 1990; Humphrey et al., 2004; McElree et al., 2006; Rapp et al., 2011; Weiland et al., 2012). In addition Experiment 2 tested whether interpreting familiar metonyms imposes a processing cost when compared to a different baseline. Whereas place-for-institution metonyms (e.g., *offended the college*) refer indirectly to people (e.g., *the individuals who make up the administration of the college*), these metonyms can be substituted with an NP that refers directly to a person or a group of people (e.g., *offended the leader*; see 6a and 6b). This comparison offers an additional test of models of figurative-language processing. Again, whereas the indirect-access model predicts that readers will encounter difficulty with a metonymic expression compared to a literal expression, the direct-access model instead predicts that there should be no difference.

(6a) *Sometime in August, the journalist offended the leader after he had published that negative article.* (Person-Argument)

(6b) *Sometime in August, the journalist offended the honor of the leader after he had published that negative article.* (Person-Adjunct)

(6c) *Sometime in August, the journalist offended the college after he had bribed some crooked officials.* (Metonym-Argument)

(6d) *Sometime in August, the journalist offended the honor of the college after he had bribed some crooked officials.* (Metonym-Adjunct)

It should be noted that our manipulation of sentence structure also introduces changes in the semantic content of the sentences in the Argument conditions compared to the Adjunct conditions. That is, whereas all conditions contain a verb (e.g., *offended*) that indicates the need for an animate patient or an entity that can be interpreted as having animate qualities, the Adjunct conditions also contain an additional content word (e.g., *honor*) that may further

cue the reader that the target word should be interpreted as an animate entity. We return to this issue in the Discussion.

Method

Participants—Forty-four students at the University of North Carolina at Chapel Hill participated in this experiment in exchange for course credit. They were all native English speakers and had normal or corrected-to-normal vision.

Materials—Each participant was presented with 32 experimental sentences and 92 filler sentences. The experimental sentences were modified versions of the experimental sentences used in Experiment 1. See (6) for an example. The critical NPs for the metonymic condition were the same familiar metonyms as those used in Experiment 1 (e.g., *the college*). In addition to the metonymic condition, we introduced a condition that directly named a person (e.g., *the leader*). The critical NPs could appear as the object of the verb, as in Experiment 1, or as part of an adjunct phrase. The adjunct condition was constructed by selecting a new NP that could serve as the object of the verb and that could be attributed either to a person or to an institution via a prepositional phrase (e.g., *the honor of the leader* or *the honor of the college*). The initial locative phrase and sentence subject were the same as in Experiment 1. In most cases, the postnoun region of the sentence was the same as in Experiment 1, but modifications had to be made in some cases to keep the sentence coherent. See Appendix B for a full list of materials. The critical nouns used for the person condition (e.g., *leader*) versus the metonymic condition (e.g., *college*) did not differ in frequency, $t(30) < 1$ (SUBTLEXus database, Brysbaert & New, 2009) or length, $t(30) < 1$.

Plausibility norming—As in Experiment 1, we collected plausibility ratings for the items used in Experiment 2. Twenty participants who did not participate in any other portion of this study were presented with the critical sentences up to and including the critical noun. There were four versions of each list that matched the counterbalancing used for the eye-tracking experiment. Each list also contained filler sentences. Participants were instructed to indicate how likely they believed the events described by the sentence were on a scale from 1 (highly unlikely) to 7 (highly likely). Each participant saw the sentences in a different random order. The mean ratings for each condition were 5.4 (Person-Argument), 5.3 (Person-Adjunct), 5.3 (Metonym-Argument), and 5.3 (Metonym-Adjunct). There were no significant differences between any condition, all ts < 1.2, all ps > .25. Thus, any differences in reading times between sentences with people NPs versus metonyms and any influence of sentence structure on these reading times cannot be attributed to differences in plausibility.

Predictability—The stimuli from Experiment 2 were assessed for predictability of the critical noun just as described in Experiment 1. Sixteen participants provided sentence completions. As in Experiment 1, the percentages of responses that matched the critical words were extremely low across all conditions: 2.7% (Person-Argument), 1.6% (Person-Adjunct), 0.8% (Metonym-Argument), and 1.6% (Metonym-Adjunct).

Procedure—All aspects of the eye-tracking procedure were identical to Experiment 1.

Analysis—As in Experiment 1, data analysis of Experiment 2 focused on measures of gaze duration, right-bounded reading time, regression-path duration, and total time. We defined three regions of interest—the prenoun region, critical NP, and postnoun region—just as we did in Experiment 1. Finally, we employed the same data-exclusion criteria that were adopted in Experiment 1, again eliminating 1.6% of the data.

Results

Comprehension-question accuracy—Mean comprehension-question accuracies for each condition were as follows: Person-Argument (95%), Person-Adjunct (95%), Metonym-Argument (94%), Metonym-Adjunct (93%). As in Experiment 2, data were arcsine-transformed before calculating inferential statistics. There were no significant main effects or interactions.

Prenoun region—Mean reading times for the three regions of interest are displayed in Table 2. Reading times from all trials were included, regardless of whether the comprehension question was answered correctly. No statistically significant main effects or interactions were observed in the prenoun region for gaze duration, right-bounded reading time, or regression-path duration, demonstrating that processing difficulty for the four conditions did not differ prior to encountering the critical NP.

In contrast, there was a main effect of NP type for total time that was significant in the subject analysis and marginal in the item analysis, $F_1(1, 43) = 7.56$, $MSE = 22{,}131$, $p < .01$; $F_2(1, 31) = 3.16$, $MSE = 43{,}626$, $p < .09$, indicating that there were longer reading times on the prenoun region when the critical NP was a metonym compared to when it was a person. There was no main effect of sentence structure, $F_1(1, 43) = 1.67$, $MSE = 28{,}403$, $p > .20$; $F_2(1, 31) = 2.26$, $MSE = 17{,}095$, $p > .14$, nor was there an interaction between NP type and sentence structure, $F_1(1, 43) = 1.22$, $MSE = 29{,}218$, $p > .25$; $F_2(1, 31) = 1.56$, $MSE = 19{,}425$, $p > .20$.

Critical NP—Analysis of gaze duration on the critical NP revealed no significant main effects or interactions, all ps > .10.

There was a main effect of NP type in right-bounded reading time, $F_1(1, 43) = 20.73$, $MSE = 5{,}946$, $p < .001$; $F_2(1, 31) = 5.67$, $MSE = 16{,}560$, $p < .05$,with longer reading times on metonymic NPs compared to NPs that named people. The main effect of sentence structure was not significant, $F_1(1, 43) < 1$; $F_2(1, 31) < 1$. However, the interaction between NP type and sentence structure was marginally significant in the subject analysis and fully significant in the item analysis, $F_1(1, 43) = 2.70$, $MSE = 6{,}746$, $p = .10$; $F_2(1, 31) = 5.56$, $MSE = 2{,}785$, $p < .05$. Follow-up comparisons revealed that metonymic NPs were more difficult to process than people NPs when they appeared as an argument of the verb, $t_1(43) = 5.24$, $p < .001$; $t_2(31) = 3.04$, $p < .01$, but that there was no difference when the critical NP appeared as part of an adjunct phrase, $t_1(43) = 1.67$, $p > .10$; $t_2(31) = 1.33$, $p > .19$.

Regression-path duration on the critical NP did not show significant main effects of sentence structure or NP type. Again, however, the interaction between these two factors was significant in the item analysis, $F_1(1, 43) = 1.77$, $MSE = 25{,}147$, $p > .15$; $F_2(1, 31) = 4.95$, $MSE = 10{,}778$, $p < .05$. Follow-up contrasts again showed that metonymic NPs were more difficult to process than people NPs when they appeared as an argument of the verb, $t_1(43) = 2.21$, $p < .05$; $t_2(31) = 2.01$, $p = .05$, but that there was no difference when the critical NP appeared as part of an adjunct phrase, ts < 1.

Analysis of total time on the critical NP revealed a robust effect of NP type, such that metonymic NPs were more difficult than people NPs, $F_1(1, 43) = 35.49$, $MSE = 11{,}686$, $p < .001$; $F_2(1, 31) = 8.21$, $MSE = 38{,}248$, $p < .01$. Once again, there was a marginally significant interaction between NP type and sentence structure, $F_1(1, 43) = 2.89$, $MSE = 13{,}383$, $p < .10$; $F_2(1, 31) = 3.35$, $MSE = 8{,}923$, $p < .08$. Metonymic NPs were more difficult than people NPs regardless of whether the NP appeared as an argument of the verb, $t_1(43) = 4.71$, $p < .001$; $t_2(31) = 3.08$, $p < .005$, or as part of an adjunct, $t_1(43) = 3.31$, $p < .005$; $t_2(31) = 2.00$, $p = .05$. In contrast, there was evidence (in the subject analysis) that

metonymic NPs were more difficult as arguments than adjuncts, $t_1(43) = 2.10$, $p < .05$; $t_2(31) = 1.46$, $p > .15$, but there was no such difference for people NPs, $ts < 1$.

Thus, measures of right-bounded reading time and total time on the critical NP showed main effects of NP type such that familiar metonyms were more difficult to process than NPs that named people. These main effects were qualified by interactions in measures of right-bounded reading time, regression-path duration, and total time on this region showing that metonyms were more difficult to process when they appeared as the argument of the verb than when they appeared as part of an adjunct phrase, but that there was no such effect of sentence structure on the processing of people NPs.

Postnoun region—Analysis of gaze duration on the postnoun region revealed a main effect of sentence structure (marginal in the item analysis), $F_1(1, 43) = 4.15$, $MSE = 3.782$, $p < .05$; $F_2(1, 31) = 3.46$, $MSE = 5{,}821$, $p < .08$, with longer reading times on arguments than adjuncts. There was no main effect of NP type; however, the interaction between NP type and sentence structure was marginally significant in the subject analysis, $F_1(1, 43) = 3.52$, $MSE = 3{,}911$, $p < .07$; $F_2(1, 31) < 1$. This pattern was driven by longer gaze durations in the condition where a person NP appeared as an argument of the verb, relative to the other three conditions[3].

Right-bounded reading time showed a main effect of sentence structure on the postnoun region, such that arguments were overall more difficult than adjuncts, $F_1(1, 43) = 6.01$, $MSE = 7{,}622$, $p < .05$; $F_2(1, 31) = 5.16$, $MSE = 8{,}535$, $p < .05$. The main effect of NP type and the interaction between NP type and sentence structure were not significant.

There was a fully significant interaction between NP type and sentence structure in regression-path duration on the postnoun region, $F_1(1, 43) = 4.29$, $MSE = 19{,}457$, $p < .05$; $F_2(1, 31) = 4.25$, $MSE = 15{,}445$, $p < .05$. Follow-up contrasts revealed that metonymic NPs were more difficult to process than people NPs when they appeared as the object of the verb, $t_1(43) = 2.62$, $p < .05$; $t_2(31) = 2.87$, $p < .01$, but not when they appeared as part of an adjunct phrase, $ts < 1$. Furthermore, metonymic NPs were more difficult to process as arguments than adjuncts, $t_1(43) = 2.81$, $p < .01$; $t_2(31) = 2.86$, $p < .01$, whereas there was no such difference for people NPs, $ts < 1$. Thus, participants were more likely to experience processing difficulty in the region immediately following the critical NP when the NP was a metonym that appeared as an argument, compared to the other three conditions.

Total time on the postnoun region showed a main effect of sentence structure, such that arguments were more difficult than adjuncts, $F_1(1, 43) = 11.17$, $MSE = 12{,}956$, $p < .005$;

[3]The pattern observed on this gaze-duration measure is reversed when the more encompassing measure of regression-path duration is explored, a change which suggests differences across conditions in the likelihood that the eyes moved forward after first-pass reading of the postnoun region. This suggestion was born out by the finding that the proportion of trials with first-pass regressions from this region was lowest in the Person-Argument condition (i.e., 9%, compared with 21%, 11%, and 14% in the Metonym-Argument, Person-Adjunct, and Metonym-Adjunct conditions, respectively). Further, both the number of first-pass fixations on the postnoun region and their summed durations were greater on trials followed by progressive saccades than by regressive saccades [number of fixations: $F_1(1, 43) = 27.36$, $MSE = 0.55$, $p < .001$; $F_2(1, 31) = 68.74$, $MSE = 0.21$, $p < .001$; gaze duration: $F_1(1, 43) = 13.88$, $MSE = 44{,}479$, $p < .01$; $F_2(1, 31) = 40.62$, $MSE = 16{,}054$, $p < .001$]. This difference is readily explained as due to readers prematurely terminating their first-pass reading of the postnoun region in order to return to an earlier region of text when they experienced difficulty understanding the meaning of those earlier regions. This difficulty was least likely to be experienced in the Person-Argument condition, which could have the paradoxical effect of elevating average gaze durations for that region relative to the others. This account was tested by analyzing gaze duration on the postnoun region only for those trials where the eyes progressed after first-pass reading of the postnoun region. Restricting the analysis in this way completely eliminated the interaction between NP type and sentence structure, $F_1(1, 43) < 1$; $F_2(1, 31) < 1$.

We also analyzed skipping rates on the critical NP to examine the possibility that the longer gaze durations in the postnoun region for the Person-Argument condition may have been the result of different fixation patterns for this condition compared to the other conditions. Skipping rates were as follows: Person-Argument (2%), Metonym-Argument (3%), Person-Adjunct (4%), Metonym-Adjunct (5%). There were no significant main effects or interactions.

$F_2(1, 31) = 7.23$, $MSE = 15{,}984$, $p < .05$. The main effect of NP type and the interaction between NP type and sentence structure were not significant.

Discussion

Experiment 2 replicated the finding from Experiment 1 that metonyms are harder to process than literal expressions. Whereas Experiment 1 compared familiar metonyms that were used in their figurative sense (e.g., *offended the college*) versus their literal sense (e.g., *photographed the college*), Experiment 2 compared familiar metonyms to nouns that referred directly to people (e.g., *offended the leader*).

Critically, Experiment 2 also demonstrated that the degree of processing difficulty depends on sentence structure. Readers experienced greater difficulty with metonymic nouns than nouns that named people when the critical NP appeared as the object of the verb. In contrast, when the critical NP appeared as part of an adjunct phrase, the processing difference between metonyms and people was reduced or eliminated completely. There was evidence for this interaction effect on the critical NP itself in right-bounded reading time, regression-path duration, and total time; however, the effect was strongest in regression-path duration on the postnoun region, indicating a tendency for participants to experience greater processing difficulty for the Metonym-Argument condition than the other three conditions in the region immediately following the metonym and then spend extra time going back to reread earlier parts of the sentence. Our finding of reduced difficulty for the processing of metonyms that appear as part of an adjunct phrase is consistent with the pattern of effects predicted by a direct-access model of figurative-language processing.

We propose that metonyms are especially difficult to process when they appear as the argument of a verb because this position is focused by the sentence structure. Given the verb *offended*, the reader needs to understand who offended whom in order to obtain a basic understanding of the sentence. In this case, the “whom” is an inanimate noun used metonymically (*college*), which requires a noncanonical interpretation, leading to extra processing. In contrast, when the object of the verb is a noun that represents a human characteristic (*honor*), this becomes a focus of the sentence, whereas the adjunct phrase (*of the college*) is less important and thus is not processed as deeply. As noted above, the Adjunct condition contained two sources of semantic information that pointed to the need to interpret the critical NP as having animate qualities (e.g., *offended the honor of the college*), whereas the Argument condition contained only one (e.g., *offended the college*). It could be argued that this extra semantic material—not the difference in sentence structure—causes the reduction in processing difficulty. Although the current experiment does not rule out this possibility, it is not obvious how the mere presence of two sources of semantic information should lead to easier processing. In fact, it could also be argued that two sources of semantic information would have the opposite effect, leading the reader to more strongly expect an animate patient, thereby highlighting the incongruity of a metonymic target word rather than facilitating its figurative interpretation. The presence of additional semantic material might aid figurative-language processing in cases where it helps identify the needed figurative interpretation rather than simply reinforcing the need for such an interpretation. That sort of facilitation may be operating in the Adjunct condition, where the structure of the sentence serves to direct the reader’s attention toward a particular feature of the metonym (e.g., *honor*), while deemphasizing the metonym itself.

General Discussion

This study produced three main findings. First, Experiment 1 showed that familiar metonyms are more difficult to process when they appear in a figurative context (e.g., *offended the college*) than when they appear in a literal context (e.g., *photographed the*—

college) an effect that emerged early in the eye-tracking record. Differences in the processing of familiar metonyms versus unfamiliar metonyms (e.g., *offended the pyramid*) did not emerge until late in the eye-tracking record. Second, Experiment 2 showed that the difficulty associated with processing a familiar metonym (e.g., *offended the college*) also emerges when compared against a noun that explicitly names a person (e.g., *offended the leader*). Finally, our results demonstrate that the difficulty of processing a familiar metonym was reduced when it appeared as part of an adjunct phrase (e.g., *offended the honor of the college*) compared to when it appeared as an argument of the verb. These findings show that the pattern of performance predicted by the indirect-access model of figurative-language processing is found for metonyms that are arguments but that the pattern of performance predicted by the direct-access model of figurative-language processing is found for metonyms that are adjuncts.

Findings on Metonymic Processing

Previous research on the processing of metonymy has produced inconsistent results, with some studies showing that familiar metonyms are no more difficult to process than literal expressions and others showing that they are more difficult. While these studies have employed a variety of different methods and have used stimuli that differ on a number of dimensions, we believe that the moderating effect of sentence structure on metonymic processing offers a new perspective on how figurative language is processed and helps explain previous inconsistencies in the literature. As discussed previously, Frisson and Pickering (1999) found only weak evidence that familiar metonyms (e.g., *rejected by the college*) are more difficult to process than literal expressions (e.g., *stepped inside the college*), but their target words sometimes appeared as an argument of the verb and sometimes appeared as part of an adjunct phrase. The results of the current study suggest that the weak effects reported by Frisson and Pickering, and of other experiments using the same materials (Humphrey et al., 2004), might be due to structural variation within their materials. In sentences where the critical word was an argument, metonymic interpretation may have been more difficult than literal interpretation, whereas it was not so in sentences where the critical word was an adjunct, with this second type of sentence structure diluting the impact of the first. Variation in sentence structure might also account for the absence of differences in the processing of literal expressions and familiar place-for-event or producer-for-product metonyms (Frisson & Pickering, 1999, Experiment 2; Frisson & Pickering, 2007). In contrast, studies demonstrating greater difficulty in the processing of metonymic and literal expressions (Gibbs, 1990; Rapp et al., 2011; Weiland et al., 2012) have tended to use target nouns as arguments of the predicates that induced the metonymic or literal interpretation (e.g., *The scalpel was sued for malpractice; The glove at third base has to be replaced*; Gibbs, 1990).

Nonetheless, it is important to note that using the same method as the current studies, eye-tracking during reading, McElree et al. (2006) found no evidence of difficulty in comprehension of producer-for-product metonyms (e.g., *The gentleman read Dickens…*) as compared to literal controls (e.g., *The gentleman spotted Dickens…*) even though the critical word consistently appeared as the object of the context-providing verb. The discrepancy between this finding and those reported here is unlikely to be due to the use of different types of metonyms (producer-for-product versus place-for-institution) as studies using other methods have shown difficulty in processing producer-for-product metonyms that appear as arguments (Rapp et al., 2011; Weiland et al., 2012). One possible explanation is that the discrepancy is due to greater difficulty in processing the literal sentences in McElree et al.'s study as compared to those reported here. McElree et al.'s literal condition consisted of people interacting with famous deceased writers (e.g., *The educated slave greeted Aristotle…; The retired professor welcomed Freud…*), whereas those in the current study

involved conventional action-place pairings (e.g., *photographed the college; entered the academy*; Experiment 1) or human role terms that matched the metonyms in length and frequency (*offended the leader; addressed the secretary*; Experiment 2). Further research will be needed to determine whether this explanation is valid or whether the discrepancy has some other basis. Though they found no evidence of difficulty in metonymic processing, McElree et al. did find greater difficulty when understanding required object-for-event coercion (e.g., *The gentleman started Dickens…*versus *The gentleman read Dickens…*). Thus, the McElree et al. pattern of results presents a challenge to our proposal that comprehension of figurative language, whether it involves coercion or metonymy, is difficult because of the need to derive a noncanonical interpretation of a word that allows it to make sense in the context. The degree of processing difficulty might vary with the type of figurative language or for particular expressions, but this processing difficulty should be present to some degree when the figurative expression appears as a sentential argument.

Sentence Structure and Metonymic Processing

Several psycholinguistic accounts have proposed that sentence structure is one important cue that helps guide language processing and indicates to the comprehender which elements of the sentence should be processed more deeply than others (e.g., Baker & Wagner, 1987; Ferreira et al., 2002; Gordon & Hendrick, 1998; Sanford & Sturt, 2002). We have argued that the pairing of an inanimate subject with an action verb (e.g., *the pistol injured*) or the use of a metonym as the object of a verb (e.g., *offended the college*) cause processing difficulty because the structure of the sentence promotes deep interpretation of a verbal predicate in relation to its arguments, which in these examples requires a noncanonical semantic interpretation of the argument. In particular, a verb such as *offend* typically requires an object that is human—capable of perceiving some wrongdoing and experiencing a negative emotional reaction. When instead an inanimate place such as *the college* appears as the object, the comprehender must search for an alternate meaning of this word that satisfies the semantic requirements of the verb. Accordingly, the comprehender comes to interpret *the college* not as a literal physical place, but rather as an institution made of humans who experienced offense. Importantly, this search for an appropriate meaning of *offended the college* requires additional processing time in comparison to when the object is a human (e.g., *offended the leader*) or when the verb selects an argument that is consistent with the literal meaning of the metonym (e.g., *photographed the college*). Similarly, *honor* can easily serve as the object of *offended*. Although not animate *per se*, *honor* refers to a human value that can suffer offense. Thus, in the phrase *offended the honor of the college*, the word *honor* becomes closely tied to the action *offend*, whereas *of the college* is a modifier of *honor* that is not tightly bound to the main verb of the sentence, and so it is processed less deeply.

In sum, we propose that syntactic structure is an important aspect of a sentence that guides processing and provides cues as to which constituents are more important than others. When the structure of the sentence places a metonym in a focused position, such as the object of the verb, the comprehender will experience enhanced semantic difficulty due to the need to derive a noncanonical interpretation of this word. In contrast, adjunct phrases are not as important to the overall meaning of the sentence, and so a metonym in an adjunct phrase is typically not processed at a deep semantic level.

We believe that there are several possible mechanisms that might account for this pattern of effects. First, in line with Frisson and Pickering's account (Frisson, 2009; Frisson & Pickering, 1999, 2001), it may be that when a metonym appears in an adjunct phrase the reader does not fully distinguish between literal and figurative interpretations initially, but rather adopts a semantically underspecified representation and, if necessary, selects the intended meaning at a later stage of processing. Because the information contained in an

adjunct phrase is seen as less important to the overall meaning of the sentence, it is possible that an underspecified interpretation is sufficient in most cases. A second possibility is that explicit mention of a feature of the metonym (e.g., *honor* in *offended the honor of the college*) makes that feature particularly salient, thereby reducing focus on the metonym itself. From this perspective, *honor* is a known but not usually a primary characteristic of a college. By promoting this property to a prominent position in the sentence, the comprehender becomes particularly focused on this now-salient aspect of *college* at the expense of processing the information in the adjunct. Finally, the basic structure of an adjunct seems to indicate that the information it conveys is presupposed. That is, a phrase such as *of the college* implies that *the college* has already been brought into the discourse (i.e., is "given") and is now appearing in the sentence simply to modify a new entity (e.g., *the honor*). The use of a definite rather than an indefinite article may further suggest that the critical word is presupposed; however, the definite article was also used in the Argument conditions. Thus, any influence from the article indicating that the critical word was presupposed was consistent across all conditions. We propose that the structure of the adjunct phrase is an additional source of information that may cue the reader that the information it conveys is presupposed, as it is being presented not as a focal point of the sentence, but rather as a modifier. Underspecification of meaning, promotion of a relevant property, and presupposition are all ways that sentence structure may cause a noncanonical semantic interpretation to be processed less deeply. These explanations are not necessarily mutually exclusive; each may explain some aspect of reduction in depth of processing.

Conclusion

Debates over how figurative language is processed have shifted from accounts where a literal interpretation must be accessed before a figurative interpretation (e.g., Clark & Lucy, 1979; Grice, 1975; Janus & Bever, 1985; Searle, 1979) to accounts where familiar figurative expressions do not require extra processing effort (e.g., Gerrig & Healy, 1983; Gibbs, 1994; Gibbs & Gerrig, 1989; Gildea & Glucksberg, 1983; Glucksberg, 1991, 2003; Glucksberg et al., 1982; Keysar, 1989; Inhoff et al., 1984; Ortony et al., 1978; Shinjo & Myers, 1987), with most of this research investigating the processing of metaphor. More recent studies investigating other types of language have provided growing evidence that figurative expressions often tend to be more difficult to process than literal expressions. These include studies on the processing of idioms (Cacciari & Tabossi, 1988), proverbs (Honeck, Welge, & Temple, 1998; Temple & Honeck, 1999), and irony (Dews & Winner, 1999; Giora, Fein, & Schwartz, 1998; Filik & Moxey, 2010; Schwoebel, Dews, Winner, & Srinivas, 2000). Even in the realm of metaphor, several recent studies using electrophysiology have suggested that the processing of metaphorical expressions is more effortful than the processing of literal expressions (Coulson & Van Petten, 2002, 2007; De Grauwe, Swain, Holcomb, Ditman, & Kuperberg, 2010; Lai, Curran, & Menn, 2009; Tartter, Gomes, Dubrovsky, Molholm, & Stewart, 2002). The results of the current study corroborate and extend these previous findings in demonstrating that metonyms—both familiar and unfamiliar—are more difficult to process than literal expressions when they are arguments of the predicate that induces the metonymic interpretation. Importantly, the difficulty associated with processing a familiar metonym was reduced when it appeared in a position that is less central to the structure of the sentence. These findings indicate that sentence structure is a key factor to consider in developing psycholinguistic models that explain the processing of figurative language.

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References

Baker L, Wagner JL. Evaluating information for truthfulness: The effects of logical subordination. Memory & Cognition. 1987; 15:247–255. [PubMed: 3600265]

Betancort M, Carreiras M, Sturt P. The processing of subject and object relative clauses in Spanish: An eye-tracking study. The Quarterly Journal of Experimental Psychology. 2009; 62:1915–1929. [PubMed: 19424908]

Boland JE, Blodgett A. Argument status and PP-attachment. Journal of Psycholinguistic Research. 2006; 35:385–403. [PubMed: 16838129]

Brysbaert M, New B. Moving beyond Kucera and Francis: A critical evaluation of current word frequency norms and the introduction of a new and improved word frequency measure for American English. Behavior Research Methods. 2009; 41:977–990. [PubMed: 19897807]

Cacciari C, Tabossi P. The comprehension of idioms. Journal of Memory and Language. 1988; 27:668–683.

Clark HH, Gerrig RJ. Understanding old words with new meanings. Journal of Verbal Learning and Verbal Behavior. 1983; 22:591–608.

Clark HH, Lucy P. Understanding what is meant from what is said: A study in conversationally conveyed requests. Journal of Verbal Learning and Verbal Behavior. 1975; 14:56–72.

Clifton C Jr, Speer SR, Abney SP. Parsing arguments: Phrase structure and argument structure as determinants of initial parsing decisions. Journal of Memory and Language. 1991; 30:251–271.

Cohen, J.; Cohen, P.; West, SG.; Aiken, LS. Applied multiple regression/correlation analysis for the behavioral sciences. 3. Mahwah, NJ: Lawrence Erlbaum Associates Publishers; 2003.

Coulson S, Van Petten C. Conceptual integration and metaphor: An ERP study. Memory & Cognition. 2002; 30:958–968. [PubMed: 12450098]

Coulson S, Van Petten C. A special role for the right hemisphere in metaphor comprehension? ERP evidence from hemifield presentation. Brain Research. 2007; 1146:128–145. [PubMed: 17433892]

De Grauwe S, Swain A, Holcomb PJ, Ditman T, Kuperberg GR. Electrophysiological insights into the processing of nominal metaphors. Neuropsychologia. 2010; 48:1965–1984. [PubMed: 20307557]

Dews S, Winner E. Obligatory processing of literal and nonliteral meanings in verbal irony. Journal of Pragmatics. 1999; 31:1579–1599.

Ferreira F, Bailey KGD, Ferraro V. Good-enough representations in language comprehension. Current Directions in Psychological Science. 2002; 11:11–15.

Filik R, Moxey LM. The on-line processing of written irony. Cognition. 2010; 116:421–436. [PubMed: 20598677]

Frisson S. Semantic underspecification in language processing. Language and Linguistics Compass. 2009; 3:111–127.

Frisson S, McElree B. Complement coercion is not modulated by competition: Evidence from eye movements. Journal of Experimental Psychology: Learning, Memory, and Cognition. 2008; 34:1–11.

Frisson S, Pickering MJ. The processing of metonymy: Evidence from eye movements. Journal of Experimental Psychology: Learning, Memory, and Cognition. 1999; 25:1366–1383.

Frisson S, Pickering MJ. Obtaining a figurative interpretation of a word: Support for underspecification. Metaphor and Symbol. 2001; 16:149–171.

Frisson S, Pickering MJ. The processing of familiar and novel senses of a word: Why reading Dickens is easy but reading Needham can be hard. Language and Cognitive Processes. 2007; 22:595–613.

Gerrig RJ. The time course of sense creation. Memory & Cognition. 1989; 17:194–207. [PubMed: 2927317]

Gerrig RJ, Healy AF. Dual processes in metaphor understanding: Comprehension and appreciation. Journal of Experimental Psychology: Learning, Memory, and Cognition. 1983; 9:667–675.

Ghio, M.; Bott, L.; Schumacher, PB.; Bambini, V. Different processing dynamics for metaphor and metonymy. Poster presented at the 25th Annual CUNY Conference on Human Sentence Processing; New York. March 14–16; 2012.

Gibbs RW. Comprehending figurative referential descriptions. Journal of Experimental Psychology: Learning, Memory, and Cognition. 1990; 16:56–66.

Gibbs, RW. The poetics of mind: Figurative thought, language, and understanding. Cambridge, England: Cambridge University Press; 1994.

Gibbs RW, Gerrig RJ. How context makes metaphor comprehension seem special. Metaphor and Symbolic Activity. 1989; 3:145–158.

Gildea P, Glucksberg S. On understanding metaphor: The role of context. Journal of Verbal Learning and Verbal Behavior. 1983; 22:577–590.

Giora R, Fein O, Schwartz T. Irony: Graded salience and indirect negation. Metaphor and Symbol. 1998; 13:83–101.

Glucksberg S. Beyond literal meanings: The psychology of allusion. Psychological Science. 1991; 2:146–152.

Glucksberg, S. Understanding figurative language: From metaphors to idioms. Oxford, United Kingdom: Oxford University Press; 2001.

Glucksberg S. The psycholinguistics of metaphor. Trends in Cognitive Sciences. 2003; 7:92–96. [PubMed: 12584028]

Glucksberg S, Gildea P, Bookin HA. On understanding nonliteral speech: Can people ignore metaphors? Journal of Verbal Learning and Verbal Behavior. 1982; 21:85–98.

Gordon PC, Hendrick R. The representation and processing of coreference in discourse. Cognitive Science. 1998; 22:389–424.

Gordon PC, Hendrick R, Johnson M, Lee Y. Similarity-based interference during language comprehension: Evidence from eye tracking during reading. Journal of Experimental Psychology: Learning, Memory, and Cognition. 2006; 32:1304–1321.

Gordon PC, Lowder MW. Complex sentence processing: A review of theoretical perspectives on the comprehension of relative clauses. Language and Linguistics Compass. 2012; 6:403–415.

Grice, P. Logic and conversation. In: Cole, P.; Morgan, J., editors. Syntax and semantics. Vol. 3. New York: Academic Press; 1975. p. 41-58.

Honeck RP, Welge J, Temple JG. The symmetry control in tests of the standard pragmatic model: The case of proverb comprehension. Metaphor and Symbol. 1998; 13:257–273.

Humphrey HE, Kemper S, Radel JD. The time course of metonymic language text processing by older and younger adults. Experimental Aging Research. 2004; 30:75–94. [PubMed: 14660334]

Inhoff AW, Lima SD, Carroll PJ. Contextual effects on metaphor comprehension in reading. Memory & Cognition. 1984; 12:558–567. [PubMed: 6085393]

Janus RA, Bever TG. Processing of metaphoric language: An investigation of the three-stage model of metaphor comprehension. Journal of Psycholinguistic Research. 1985; 14:473–487.

Johnson ML, Lowder MW, Gordon PC. The sentence-composition effect: Processing of complex sentences depends on the configuration of common noun phrases versus unusual noun phrases. Journal of Experimental Psychology: General. 2011; 140:707–724. [PubMed: 21767046]

Keysar B. On the functional equivalence of literal and metaphorical interpretations in discourse. Journal of Memory and Language. 1989; 28:375–385.

Lai VT, Curran T, Menn L. Comprehending conventional and novel metaphors: An ERP study. Brain Research. 2009; 1284:145–155. [PubMed: 19505446]

Lakoff, G.; Johnson, M. Metaphors we live by. Chicago: University of Chicago Press; 1980.

Lee Y, Lee H, Gordon PC. Linguistic complexity and information structure in Korean: Evidence from eye-tracking during reading. Cognition. 2007; 104:495–534. [PubMed: 16970936]

Lowder MW, Gordon PC. The pistol that injured the cowboy: Difficulty with inanimate subject-verb integration is reduced by structural separation. Journal of Memory and Language. 2012; 66:819–832.

McElree B, Frisson S, Pickering MJ. Deferred interpretations: Why starting Dickens is taxing but reading Dickens isn't. Cognitive Science. 2006; 30:113–124.

Nunberg, G. The pragmatics of reference. Bloomington: Indiana University Linguistic Club; 1978.

Onishi KH, Murphy GL. Metaphoric reference: When metaphors are not understood as easily as literal expressions. Memory & Cognition. 1993; 21:763–772. [PubMed: 8289654]

Ortony A, Schallert DL, Reynolds RE, Antos SJ. Interpreting metaphors and idioms: Some effects of context on comprehension. Journal of Verbal Learning and Verbal Behavior. 1978; 17:465–477.

Pickering MJ, Traxler MJ. Plausibility and recovery from garden paths: An eye- tracking study. Journal of Experimental Psychology: Learning, Memory, and Cognition. 1998; 24:940–961.

Pickering MJ, Traxler MJ. Strategies for processing unbounded dependencies: Lexical information and verb-argument assignment. Journal of Experimental Psychology: Learning, Memory, and Cognition. 2001; 27:1401–1410.

Pustejovsky, J. The generative lexicon. Cambridge, MA: MIT Press; 1995.

Rapp AM, Erb M, Grodd W, Bartels M, Markert K. Neural correlates of metonymy resolution. Brain and Language. 2011; 119:196–205. [PubMed: 21889196]

Sanford AJ, Sturt P. Depth of processing in language comprehension: Not noticing the evidence. Trends in Cognitive Sciences. 2002; 6:382–386. [PubMed: 12200180]

Schütze CT, Gibson E. Argumenthood and English prepositional phrase attachment. Journal of Memory and Language. 1999; 40:409–431.

Schwoebel J, Dews S, Winner E, Srinivas K. Obligatory processing of the literal meaning of ironic utterance: Further evidence. Metaphor and Symbol. 2000; 15:47–61.

Searle, J. Metaphor. In: Ortony, A., editor. Metaphor and thought. Cambridge, England: Cambridge University Press; 1979. p. 92-123.

Shinjo M, Myers JL. The role of context on metaphor comprehension. Journal of Memory and Language. 1987; 26:226–241.

Speer SR, Clifton C Jr. Plausibility and argument structure in sentence comprehension. Memory & Cognition. 1998; 26:965–978. [PubMed: 9796230]

Tartter VC, Gomes H, Dubrovsky B, Molholm S, Stewart RV. Novel metaphors appear anomalous at least momentarily: Evidence from N400. Brain and Language. 2002; 80:488–509. [PubMed: 11896654]

Temple JG, Honeck RP. Proverb comprehension: The primacy of literal meaning. Journal of Psycholinguistic Research. 1999; 28:41–70.

Tooley KM, Traxler MJ, Swaab TY. Electrophysiological and behavioral evidence of syntactic priming in sentence comprehension. Journal of Experimental Psychology: Learning, Memory, and Cognition. 2009; 35:19–45.

Traxler MJ. A hierarchical linear modeling analysis of working memory and implicit prosody in the resolution of adjunct attachment ambiguity. Journal of Psycholinguistic Research. 2009; 38:491–509. [PubMed: 19377881]

Traxler MJ, Morris RK, Seely RE. Processing subject and object relative clauses: Evidence from eye movements. Journal of Memory and Language. 2002; 47:69–90.

Traxler MJ, Tooley KM. Priming in sentence comprehension: Strategic or syntactic? Language and Cognitive Processes. 2008; 23:609–645.

Traxler MJ, Williams RS, Blozis SA, Morris RK. Working memory, animacy, and verb class in the processing of relative clauses. Journal of Memory and Language. 2005; 53:204–224.

Weiland, H.; Bambini, V.; Schumacher, PB. Masked priming ERP supports the role of literal meaning in figurative language comprehension. Poster presented at the 25th Annual CUNY Conference on Human Sentence Processing; New York. 2012. p. March-16.

Appendix A

The stimuli from Experiment 1 are shown below. Within each set, the first sentence represents the literal context, whereas the second sentence represents the figurative context. Within the brackets, the first NP has a familiar metonymic sense, whereas the second NP does not.

1. With determination, the two women purchased {the convent/the stadium} at the end of last April, which upset quite a lot of people.

With determination, the two women disobeyed {the convent/the stadium} at the end of last March, but did not get a lot of support.

2. Those angry protestors surrounded {the embassy/the cottage}, but not much was achieved by it.

   Those angry protestors debated {the embassy/the cottage}, but not much more could be done.

3. Finally some of the workmen painted {the store/the sheds}, which really made everything look prettier.

   Finally some of the workmen thanked {the store/the sheds}, which really was a nice gesture by them.

4. This morning, terrorists bombed {the prison/the statue} in order to gain publicity for their cause.

   This morning, terrorists threatened {the prison/the statue} in order to make their point a bit clearer.

5. Enthusiastically, the young children approached {the school/the bridge} quite early on a sunny Wednesday morning.

   Enthusiastically, the young children questioned {the school/the bridge} quite early on a rainy Monday afternoon.

6. To my dismay, the agitated senator damaged {the headquarters/the conservatory}, which was something none of us had been waiting for.

   To my dismay, the agitated senator obeyed {the headquarters/the conservatory}, which was something nobody could have prevented.

7. That same day, the husband located {the hospital/the driveway} as soon as he had been informed about the accident.

   That same day, the husband sued {the hospital/the driveway} as soon as he had heard about the mistake that was made.

8. Over the summer, the writer photographed {the college/the pyramid} after he had received an official invitation.

   Over the summer, the writer offended {the college/the pyramid} after he had bribed some crooked officials.

9. Last week the professor entered {the academy/the bedroom}, exactly as everyone had expected him to do.

   Last week the professor addressed {the academy/the bedroom}, exactly as I had wished that he would do.

10. Within an hour, that gentleman accessed {the palace/the cellar}, according to the newspapers this morning.

    Within an hour, that gentleman displeased {the palace/the cellar}, according to the latest gossip in the tabloids.

11. Two days ago, the criminal destroyed {the consulate/the apartment}, but then he got arrested the same day.

    Two days ago, the criminal notified {the consulate/the apartment}, but then he ran away in a great hurry.

12. During the protest, the strikers encircled {the institute/the roadblock}, which was not something that I advised them to do.

During the protest, the strikers insulted {the institute/the roadblock}, which was not a very sensible idea after all.

13. An hour later, the businessmen found {the treasury/the building}, which was not what we had anticipated.

An hour later, the businessmen greeted {the treasury/the building}, which was not exactly what we wanted.

14. Sometime last night the thief escaped {the court/the tower}, just as his accomplice had done before him.

Sometime last night the thief provoked {the court/the tower}, just as his partner had instructed him to do.

15. During vacation, those British visitors toured {the gallery/the highway} and did not encounter any major problems.

During vacation, those British visitors scolded {the gallery/the highway} and did not exactly enjoy the experience.

16. On Labor Day, many sightseers explored {the university/the lighthouse}, although it was an official holiday.

On Labor Day, many sightseers contacted {the university/the lighthouse}, although it was late in the afternoon.

17. To my amazement, the executives purchased {the convent/the stadium} at the end of last April, which upset quite a lot of people.

To my amazement, the executives disobeyed {the convent/the stadium} at the end of last March, but did not get a lot of support.

18. Three days ago, the activists surrounded {the embassy/the cottage}, but not much was achieved by it.

Three days ago, the activists debated {the embassy/the cottage}, but not much more could be done.

19. Reluctantly one of the boys painted {the store/the sheds}, which really made everything look prettier.

Reluctantly one of the boys thanked {the store/the sheds}, which really was a nice gesture by him.

20. Last year rebels bombed {the prison/the statue} in order to gain publicity for their cause.

Last year rebels threatened {the prison/the statue} in order to make their point a bit clearer.

21. After the incident, the concerned father approached {the school/the bridge} quite early on a sunny Wednesday morning.

After the incident, the concerned father questioned {the school/the bridge} quite early on a rainy Monday afternoon.

22. To my surprise, the guards damaged {the headquarters/the conservatory}, which was something none of us had been waiting for.

To my surprise, the guards obeyed {the headquarters/the conservatory}, which was something nobody could have prevented.

23. With tears in her eyes, the mother located {the hospital/the driveway} as soon as she had been informed about the accident.

With tears in her eyes, the mother sued {the hospital/the driveway} as soon as she had heard about the mistake that was made.

24. Sometime in August, the journalist photographed {the college/the pyramid} after he had received an official invitation.

Sometime in August, the journalist offended {the college/the pyramid} after he had bribed some crooked officials.

25. Yesterday afternoon the dean entered {the academy/the bedroom}, exactly as everyone had expected him to do.

Yesterday afternoon the dean addressed {the academy/the bedroom}, exactly as I had wished that he would do.

26. One year ago, the reporter accessed {the palace/the cellar}, according to the newspapers this morning.

One year ago, the reporter displeased {the palace/the cellar}, according to the latest gossip in the tabloids.

27. Last Tuesday, the traveler destroyed {the consulate/the apartment}, but then he got arrested the same day.

Last Tuesday, the traveler notified {the consulate/the apartment}, but then he ran away in a great hurry.

28. At the riot, the teenagers encircled {the institute/the roadblock}, which was not something that I advised them to do.

At the riot, the teenagers insulted {the institute/the roadblock}, which was not a very sensible idea after all.

29. Before the interview, the applicants found {the treasury/the building}, which was not what we had anticipated.

Before the interview, the applicants greeted {the treasury/the building}, which was not exactly what we wanted.

30. Before sunrise, the drug smuggler escaped {the court/the tower}, just as his accomplice had done before him.

Before sunrise, the drug smuggler provoked {the court/the tower}, just as his partner had instructed him to do.

31. For two hours, the expert toured {the gallery/the highway} and did not encounter any major problems.

For two hours, the expert scolded {the gallery/the highway} and did not exactly enjoy the experience.

32. On Tuesday, several tourists explored {the university/the lighthouse}, although it was an official holiday.

On Tuesday, several tourists contacted {the university/the lighthouse}, although it was late in the afternoon.

Appendix B

The stimuli from Experiment 2 are shown below. Within each set, the critical NP in the first sentence is a person, whereas the critical NP in the second sentence is a metonym. Each sentence was presented with and without the material in the parentheses such that the critical NP could be the object of the verb or part of an adjunct phrase.

1. With determination, the two women disobeyed (the commands of) the priest at the end of last April, which upset quite a lot of people.

   With determination, the two women disobeyed (the commands of) the convent at the end of last March, but did not get a lot of support.

2. Those angry protestors debated (the opinions of) the governor, but not much was achieved by it.

   Those angry protestors debated (the opinions of) the embassy, but not much more could be done.

3. Finally some of the workmen thanked (the clerk sent by) the manager, which really made everyone happier.

   Finally some of the workmen thanked (the clerk sent by) the store, which really was a nice gesture by them.

4. This morning, terrorists threatened (the competence of) the mayor in order to gain publicity for their cause.

   This morning, terrorists threatened (the competence of) the prison in order to make their point a bit clearer.

5. Enthusiastically, the young children questioned (the actions of) the teacher quite early on a sunny Wednesday morning.

   Enthusiastically, the young children questioned (the actions of) the school quite early on a rainy Monday afternoon.

6. To my dismay, the agitated senator obeyed (the orders of) the chairman, which was something none of us had been waiting for.

   To my dismay, the agitated senator obeyed (the orders of) the headquarters, which was something nobody could have prevented.

7. That same day, the husband sued (the student working for) the doctor as soon as he had been informed about the accident.

   That same day, the husband sued (the student working for) the hospital as soon as he had heard about the mistake that was made.

8. Over the summer, the writer offended (the honor of) the leader after he had published that negative article.

   Over the summer, the writer offended (the honor of) the college after he had bribed some crooked officials.

9. Last week the professor addressed (the concerns of) the secretary, exactly as everyone had expected him to do.

   Last week the professor addressed (the concerns of) the academy, exactly as I had wished that he would do.

10. Within an hour, that gentleman displeased (the mood of) the queen, according to the newspapers this morning.

Within an hour, that gentleman displeased (the mood of) the palace, according to the latest gossip in the tabloids.

11. Two days ago, the criminal notified (a representative of) the diplomat, but then he got arrested the same day.

Two days ago, the criminal notified (a representative of) the consulate, but then he ran away in a great hurry.

12. During the protest, the strikers insulted (the reputation of) the president, which was not something that I advised them to do.

During the protest, the strikers insulted (the reputation of) the institute, which was not a very sensible idea after all.

13. An hour later, the businessmen greeted (the interns sent by) the director, which was not what we had anticipated.

An hour later, the businessmen greeted (the interns sent by) the treasury, which was not exactly what we wanted.

14. Sometime last night the thief provoked (the authority of) the judge, just as his accomplice had done before him.

Sometime last night the thief provoked (the authority of) the court, just as his partner had instructed him to do.

15. During vacation, those British visitors scolded (the policies of) the curator and did not encounter any resistance.

During vacation, those British visitors scolded (the policies of) the gallery and did not exactly enjoy the experience.

16. On Labor Day, many sightseers contacted (the guides sent by) the administrator, although it was an official holiday.

On Labor Day, many sightseers contacted (the guides sent by) the university, although it was late in the afternoon.

17. To my amazement, the executives disobeyed (the commands of) the priest at the end of last April, which upset quite a lot of people.

To my amazement, the executives disobeyed (the commands of) the convent at the end of last March, but did not get a lot of support.

18. Three days ago, the activists debated (the opinions of) the governor, but not much was achieved by it.

Three days ago, the activists debated (the opinions of) the embassy, but not much more could be done.

19. Reluctantly one of the boys thanked (the clerk sent by) the manager, which really made everyone happier.

Reluctantly one of the boys thanked (the clerk sent by) the store, which really was a nice gesture by him.

20. Last year rebels threatened (the competence of) the mayor in order to gain publicity for their cause.

Last year rebels threatened (the competence of) the prison in order to make their point a bit clearer.

21. After the incident, the concerned father questioned (the actions of) the teacher quite early on a sunny Wednesday morning.

After the incident, the concerned father questioned (the actions of) the school quite early on a rainy Monday afternoon.

22. To my surprise, the guards obeyed (the orders of) the chairman, which was something none of us had been waiting for.

To my surprise, the guards obeyed (the orders of) the headquarters, which was something nobody could have prevented.

23. With tears in her eyes, the mother sued (the student working for) the doctor as soon as she had been informed about the accident.

With tears in her eyes, the mother sued (the student working for) the hospital as soon as she had heard about the mistake that was made.

24. Sometime in August, the journalist offended (the honor of) the leader after he had published that negative article.

Sometime in August, the journalist offended (the honor of) the college after he had bribed some crooked officials.

25. Yesterday afternoon the dean addressed (the concerns of) the secretary, exactly as everyone had expected him to do.

Yesterday afternoon the dean addressed (the concerns of) the academy, exactly as I had wished that he would do.

26. One year ago, the reporter displeased (the mood of) the queen, according to the newspapers this morning.

One year ago, the reporter displeased (the mood of) the palace, according to the latest gossip in the tabloids.

27. Last Tuesday, the traveler notified (a representative of) the diplomat, but then he got arrested the same day.

Last Tuesday, the traveler notified (a representative of) the consulate, but then he ran away in a great hurry.

28. At the riot, the teenagers insulted (the reputation of) the president, which was not something that I advised them to do.

At the riot, the teenagers insulted (the reputation of) the institute, which was not a very sensible idea after all.

29. Before the interview, the applicants greeted (the interns sent by) the director, which was not what we had anticipated.

Before the interview, the applicants greeted (the interns sent by) the treasury, which was not exactly what we wanted.

30. Before sunrise, the drug smuggler provoked (the authority of) the judge, just as his accomplice had done before him.

Before sunrise, the drug smuggler provoked (the authority of) the court, just as his partner had instructed him to do.

31. For two hours, the expert scolded (the policies of) the curator and did not encounter any resistance.

For two hours, the expert scolded (the policies of) the gallery and did not exactly enjoy the experience.

32. On Tuesday, several tourists contacted (the guides sent by) the administrator, although it was an official holiday.

On Tuesday, several tourists contacted (the guides sent by) the university, although it was late in the afternoon.

Table 1

Results of Experiment 1.

Measure (in milliseconds)	Prenoun region	Critical NP	Postnoun region
Literal-Familiar	*journalist photographed*	*the college*	*after he had*
Literal-Unfamiliar	*journalist photographed*	*the pyramid*	*after he had*
Metonymic-Familiar	*journalist offended*	*the college*	*after he had*
Metonymic-Unfamiliar	*journalist offended*	*the pyramid*	*after he had*
Gaze duration			
Literal-Familiar	543	363	377
Literal-Unfamiliar	558	369	385
Metonymic-Familiar	546	409	400
Metonymic-Unfamiliar	517	390	389
Right-bounded reading time			
Literal-Familiar	596	459	435
Literal-Unfamiliar	641	444	416
Metonymic-Familiar	607	504	450
Metonymic-Unfamiliar	606	505	483
Regression-path duration			
Literal-Familiar	642	588	568
Literal-Unfamiliar	676	548	469
Metonymic-Familiar	649	636	547
Metonymic-Unfamiliar	654	661	613
Total time			
Literal-Familiar	1,086	709	632
Literal-Unfamiliar	1,119	702	661
Metonymic-Familiar	1,201	749	655
Metonymic-Unfamiliar	1,283	918	705

Note. NP = noun phrase.

Table 2

Results of Experiment 2.

Measure (in milliseconds)	**Prenoun region**		**Critical NP**	**Postnoun region**
Person-Argument	*journalist offended*		*the leader*	*after he had*
Person-Adjunct	*journalist offended*	(*the honor of*)	*the leader*	*after he had*
Metonym-Argument	*journalist offended*		*the college*	*after he had*
Metonym-Adjunct	*journalist offended*	(*the honor of*)	*the college*	*after he had*
Gaze duration				
Person-Argument	520		341	404
Person-Adjunct	522		349	368
Metonym-Argument	536		362	378
Metonym-Adjunct	551		364	376
Right-bounded reading time				
Person-Argument	620		398	439
Person-Adjunct	620		411	408
Metonym-Argument	635		471	462
Metonym-Adjunct	645		444	429
Regression-path duration				
Person-Argument	664		515	481
Person-Adjunct	661		583	476
Metonym-Argument	670		585	570
Metonym-Adjunct	699		590	477
Total time				
Person-Argument	1,032		597	629
Person-Adjunct	1,093		602	590
Metonym-Argument	1,122		724	677
Metonym-Adjunct	1,126		669	601

Note. NP = noun phrase.